

**APPLICATION**

**FOR UNITED STATES LETTERS PATENT**

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**SPECIFICATION**

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, **Raymond Dueck**, a citizen of Canada, and **Maciej G. Wierzbowski**, a citizen of Canada, have invented a new and useful biomass gasification system of which the following is a specification:

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2  
3 **Biomass Gasification System**  
4

5  
6 **CROSS REFERENCE TO RELATED APPLICATIONS**

7 Not applicable to this application.  
8  
9

10 **STATEMENT REGARDING FEDERALLY**  
11 **SPONSORED RESEARCH OR DEVELOPMENT**

12 Not applicable to this application.  
13  
14

15 **BACKGROUND OF THE INVENTION**  
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18

19 **Field of the Invention**  
20

21 The present invention relates generally to biomass gasification and more  
22 specifically it relates to a biomass gasification system for efficiently extracting heat  
23 energy from biomass material.  
24  
25

26 **Description of the Related Art**  
27

28 Biomass gasification processes have been in use for years for converting  
29 biomass into an energy source. Biomass gasification applications include water

boiling, steam generation, drying, motive power applications (e.g. using the producer gas as a fuel in internal combustion engines), and electricity generation.

Almost all kinds of biomass with moisture content of 5-30% can be gasified. Examples of suitable biomass include forest slash, urban wood waste, lumber waste, wood chips, sawdust, straw, firewood, agricultural residue, dung and the like. Under controlled conditions, characterized by low oxygen supply and high temperatures, most biomass materials can be converted into a gaseous fuel known as "producer gas", which consists of combustible mixture of nitrogen, carbon monoxide, and hydrogen. This thermo-chemical conversion of solid biomass into gaseous fuel is called biomass gasification.

Biomass gasification has many of the advantages associated with using gaseous and liquid fuels such as clean combustion, compact burning equipment, high thermal efficiency and a good degree of control. In locations where biomass is already available at reasonable low prices (e.g. agricultural areas) or in industries using fuel wood, biomass gasifier systems offer definite economic advantages. Biomass gasification technology is also environment-friendly, because of the fuel savings and reduction in CO<sub>2</sub> emissions.

The main problems with the application of biomass gasification systems have been economic, not technical. For example, conventional biomass gasification systems are typically suitable only for large-scale operations and not small-scale operations. Also, the product from gasification is mainly a heat source, and the low value of these products in today's market is insufficient to justify the capital and operating costs of conventional biomass gasification systems. Hence, there is a need for a biomass gasification system that is efficient and cost effective to operate with low cost biomass.

An example of a patented device this is related to the present invention is illustrated in U.S. Patent 2,171,535 to Berg et al. for an incineration system for disposal of refuse having high moisture content. However, the Berg et al. patent

1 reference does not have a piston feeder structure, a rotating grate within the primary  
2 combustion chamber, a silica collector system nor an oxygen mixer between the  
3 primary combustion chamber and the secondary combustion chamber.

4  
5 While these devices may be suitable for the particular purpose to which they  
6 address, they are not as suitable for efficiently extracting heat energy from biomass  
7 material. Conventional biomass apparatus do not efficiently extract heat energy from  
8 the biomass material.

9  
10 In these respects, the biomass gasification system according to the present  
11 invention substantially departs from the conventional concepts and designs of the prior  
12 art, and in so doing provides an apparatus primarily developed for the purpose of  
13 efficiently extracting heat energy from biomass material.

1

2                   **BRIEF SUMMARY OF THE INVENTION**

3

4           In view of the foregoing disadvantages inherent in the known types of  
5 gasification apparatus now present in the prior art, the present invention provides a  
6 new biomass gasification system construction wherein the same can be utilized for  
7 efficiently extracting heat energy from biomass material.

8

9           The general purpose of the present invention, which will be described  
10 subsequently in greater detail, is to provide a new biomass gasification system that has  
11 many of the advantages of the gasification apparatus mentioned heretofore and many  
12 novel features that result in a new biomass gasification system which is not  
13 anticipated, rendered obvious, suggested, or even implied by any of the prior art  
14 gasification apparatus, either alone or in any combination thereof.

15

16           To attain this, the present invention generally comprises a primary combustion  
17 chamber, a rotating grate within the primary combustion chamber for supporting the  
18 biomass during gasification, a feeder unit in communication with the primary  
19 combustion chamber for delivering biomass, a secondary combustion chamber fluidly  
20 connected to the primary combustion chamber, an oxygen mixer positioned between  
21 the primary combustion chamber and the secondary combustion chamber, a heat  
22 exchanger and an exhaust stack.

23

24           There has thus been outlined, rather broadly, the more important features of the  
25 invention in order that the detailed description thereof may be better understood, and  
26 in order that the present contribution to the art may be better appreciated. There are  
27 additional features of the invention that will be described hereinafter and that will form  
28 the subject matter of the claims appended hereto.

29

1           In this respect, before explaining at least one embodiment of the invention in  
2 detail, it is to be understood that the invention is not limited in its application to the  
3 details of construction and to the arrangements of the components set forth in the  
4 following description or illustrated in the drawings. The invention is capable of other  
5 embodiments and of being practiced and carried out in various ways. Also, it is to be  
6 understood that the phraseology and terminology employed herein are for the purpose  
7 of the description and should not be regarded as limiting.

8  
9           A primary object of the present invention is to provide a biomass gasification  
10 system that will overcome the shortcomings of the prior art devices.

11  
12           A second object is to provide a biomass gasification system for efficiently  
13 extracting heat energy from biomass material.

14  
15           Another object is to provide a biomass gasification system that provides for  
16 usage of biomass gasification technologies within small-scale operations.

17  
18           An additional object is to provide a biomass gasification system that is capable  
19 of utilizing various types of biomass materials readily available.

20  
21           A further object is to provide a biomass gasification system that provides a cost  
22 effective alternative fuel source compared to conventional fossil fuels.

23  
24           Another object is to provide a biomass gasification system that is  
25 environmentally friendly and utilizes renewable resources.

26  
27           A further object is to provide a biomass gasification system that has efficiency  
28 ratings approaching 85%.

1           Another object is to provide a biomass gasification system that is automated  
2 and requires reduced maintenance.

3  
4           A further object is to provide a biomass gasification system that may be utilized  
5 to produce heat, mechanical power or electricity.

6  
7           Other objects and advantages of the present invention will become obvious to the  
8 reader and it is intended that these objects and advantages are within the scope of the  
9 present invention.

10  
11           To the accomplishment of the above and related objects, this invention may be  
12 embodied in the form illustrated in the accompanying drawings, attention being called  
13 to the fact, however, that the drawings are illustrative only, and that changes may be  
14 made in the specific construction illustrated and described within the scope of the  
15 appended claims.

1  
2                   **BRIEF DESCRIPTION OF THE DRAWINGS**  
3

4           Various other objects, features and attendant advantages of the present  
5 invention will become fully appreciated as the same becomes better understood when  
6 considered in conjunction with the accompanying drawings, in which like reference  
7 characters designate the same or similar parts throughout the several views, and  
8 wherein:  
9

10           FIG. 1 is a side cutaway view of the present invention.  
11

12           FIG. 2 is a side view of the fuel magazine and disintegration unit.  
13

14           FIG. 3 is a side cutaway view of the primary combustion chamber.  
15

16           FIG. 4 is a side cutaway view of the secondary combustion chamber.  
17

18           FIG. 5 is a side cutaway view of the heat exchanger.  
19

20           FIG. 6 is a side cutaway view of the exhaust stack.  
21

22           FIGS. 7a-7c illustrate the operation of the feeder unit.  
23

24           FIG. 8 is a side cutaway view of the primary combustion chamber with the fuel  
25 conveyor and disintegration unit.  
26

27           FIG. 9 is a magnified side view of the fuel conveyor feeding biomass into the  
28 feeder unit.  
29



1           FIG. 10 is a block diagram illustrating the overall control system for the present  
2 invention.  
3  
4

## DETAILED DESCRIPTION OF THE INVENTION

### *A. Overview*

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, FIGS. 1 through 10 illustrate a biomass gasification system 10, which comprises a primary combustion chamber 20, a rotating grate 21 within the primary combustion chamber 20 for supporting the biomass during gasification, a feeder unit 70 in communication with the primary combustion chamber 20 for delivering biomass, a secondary combustion chamber 40 fluidly connected to the primary combustion chamber 20, an oxygen mixer 30 positioned between the primary combustion chamber 20 and the secondary combustion chamber 40, a heat exchanger 50 and an exhaust stack 60.

### *B. Primary Combustion Chamber*

The primary combustion chamber 20 is where the primary combustion occurs thereby converting the biomass to a producer gas as shown in Figures 1, 3 and 8 of the drawings. The primary combustion chamber 20 may be comprised of various structures commonly utilized within the gasification industry.

The interior portion of the primary combustion chamber 20 is preferably circular for receiving the rotating grate 21, however various other interior cross sectional shapes may be utilized to construct the primary combustion chamber 20. The primary combustion chamber 20 is preferably formed for gasifying various types of biomass such as but not limited to forest slash, urban wood waste, lumber waste, wood chips, sawdust, straw, firewood, agricultural residue, dung and the like.

As shown in Figures 1 and 3 of the drawings, an ash disposal unit 23 is preferably positioned beneath the rotating grate 21 for removing collected ash from the

1 primary combustion chamber **20**. The ash disposal unit **23** may be comprised of any  
2 well-known technology capable of removing ash from the primary combustion  
3 chamber **20**.

#### 4 5 **C. Rotating Grate**

6 As shown in Figures 1, 3 and 8 of the drawings, the rotating grate **21** is  
7 rotatably positioned within a lower portion of the primary combustion chamber **20** for  
8 supporting the biomass during gasification. The rotating grate **21** preferably has a flat  
9 structure, however various other structures may be utilized to construct the rotating  
10 grate **21**. The rotating grate **21** may be comprised of various rigid materials capable of  
11 withstanding high temperatures such as but not limited to metal.

12  
13 The rotating grate **21** preferably includes a plurality of openings within it for  
14 allowing air to pass upwardly through the biomass positioned upon the rotating grate  
15 **21** thereby feeding the primary combustion. The openings within the rotating grate **21**  
16 may have various sizes, shapes and patterns that allow air to pass through into the  
17 biomass as can be appreciated.

18  
19 The rotating grate **21** preferably has a shape and size similar to an interior of  
20 the primary combustion chamber **20** thereby preventing biomass from falling between  
21 the outer perimeter of the rotating grate **21** and the inner wall of the primary  
22 combustion chamber **20**. The rotating grate **21** is rotatably supported within the lower  
23 portion of the primary combustion chamber **20** utilizing a support structure within the  
24 primary combustion chamber **20**. The rotating grate **21** preferably is substantially  
25 transverse with respect to a longitudinal axis of the primary combustion chamber **20** as  
26 shown in Figures 1, 3 and 8 of the drawings.

27  
28 In addition, a drive motor **27** is mechanically connected to the rotating grate **21**  
29 for rotating the rotating grate **21**. The drive motor **27** may be comprised of any well-

1 known motor structure such as electric, hydraulic and the like. The drive motor 27  
2 may be mechanically connected to the rotating grate 21 via various conventional  
3 connection means such as gears, chains, drive shaft 76 and the like.

4  
5 As shown in Figures 1 and 3 of the drawings, an air distribution system 22 is  
6 positioned within the primary combustion chamber 20 beneath the rotating grate 21 for  
7 forcing air beneath the rotating grate 21 through the openings. The air distribution  
8 system 22 draws fresh air from outside of the primary combustion chamber 20 into the  
9 primary combustion area to assist in increasing the temperature of the primary  
10 combustion. The air distribution system 22 may be comprised of various devices  
11 capable of forcing air into the primary combustion chamber 20.

#### 12 13 ***D. Feeder Unit***

14 The feeder unit 70 is in communication with the primary combustion chamber  
15 20 for delivering biomass onto the rotating grate 21 as shown in Figure 1 and 8 of the  
16 drawings. The feeder unit 70 preferably includes a disintegration unit 26 for  
17 disintegrating the biomass before entering the primary combustion chamber 20,  
18 thereby increasing the rate of breakdown for the biomass within the primary  
19 combustion chamber 20.

20  
21 The feeder unit 70 also preferably includes a biomass magazine 25 capable of  
22 storing a volume of the biomass for inputting biomass into the disintegration unit 26.  
23 For example, if straw bales are used in the present invention as the biomass, then the  
24 biomass magazine 25 would be capable of delivering bales of the straw into the  
25 disintegration upon demand. A biomass storage bin 24 stores a volume of the biomass  
26 prior to entering the biomass magazine 25. The biomass storage bin 24 may be  
27 capable of storing various volumes of biomass.

1           As shown in Figures 7a-7c of the drawings, the feeder unit **70** preferably  
2 includes a plunger member **78** that pushes the biomass into an opening surrounded by  
3 an input member **29** within the primary combustion chamber **20** onto the rotating grate  
4 **21**. The plunger member **78** is slidably positioned within the input member **29** as  
5 illustrated in Figures 7a-7c of the drawings.

6  
7           The opening within the primary combustion unit is preferably aligned with or  
8 slightly above the upper surface of the rotating grate **21** as shown in Figures 7a-7c and  
9 9 of the drawings. The input member **29** is preferably comprised of a tubular structure  
10 that allows forcing of the biomass into the primary combustion chamber **20** as shown  
11 in Figures 7a-7c of the drawings.

12  
13           The plunger member **78** moves along a path radial to the rotating grate **21** and  
14 has a cyclical action. The cyclical action of the plunger member **78** allows for new  
15 biomass to be inserted into the primary combustion chamber **20** as the rotating grate **21**  
16 rotates. As the new biomass is forced onto the rotating grate **21**, the remaining  
17 biomass is forced inwardly and the ashes pass through the rotating grate **21** to allow  
18 for the new biomass.

19  
20           The feeder unit **70** preferably includes a conveyor **28** positioned between the  
21 disintegration unit **26** and the primary combustion chamber **20** for transferring the  
22 particulate biomass into the primary combustion chamber **20**. The conveyor **28**  
23 positions the new biomass into an upper opening within the input member **29** where  
24 after the plunger member **78** drives the biomass into the primary combustion chamber  
25 **20**.

26  
27           Various well-known mechanical devices may reciprocally drive the plunger  
28 member **78**. A suitable mechanical device for driving the plunger member **78** is  
29 comprised of a flywheel **74** connected to a motor unit **72** and a drive shaft **76** attached

1 to an outer portion of the flywheel 74 and to the plunger member 78. Various other  
2 devices may be utilized to drive the plunger member 78. In addition, various other  
3 structures may be utilized to input the biomass into the primary combustion chamber  
4 20 instead of the plunger member 78.

#### 6 *E. Oxygen Mixer*

7 The oxygen mixer 30 is positioned between the primary combustion chamber  
8 20 and the secondary combustion chamber 40 as best shown in Figure 1 of the  
9 drawings. The oxygen mixer 30 is in communication with the control unit 12 and  
10 allows a desired volume of oxygen or air into the transfer tube 32 positioned between  
11 the primary combustion chamber 20 and the secondary combustion chamber 40. The  
12 transfer tube 32 preferably has a cross section substantially smaller than the primary  
13 combustion chamber 20 to create a high velocity jet stream of producer gas entering  
14 the secondary combustion chamber 40.

15  
16 The oxygen mixer 30 preferably inputs the oxygen into the producer gas  
17 emitted from the biomass in the primary combustion chamber 20 to increase the  
18 temperature of the secondary combustion to 2,000+ degrees Fahrenheit. As the  
19 producer gas increases in volume and velocity, the oxygen mixer 30 ensures that  
20 sufficient oxygen exists prior to entering the secondary combustion within the upper  
21 portion of the secondary combustion chamber 40.

#### 23 *F Secondary Combustion Chamber*

24 The secondary combustion chamber 40 is fluidly connected to the primary  
25 combustion chamber 20 via the transfer tube 32 at the upper portions thereof as best  
26 shown in Figure 1 of the drawings. The second combustion chamber preferably has a  
27 substantially smaller cross section than the primary combustion chamber 20 for  
28 increasing the velocity of the gases.

1       As the producer gas and oxygen enter the upper portion of the second  
2 combustion chamber, a secondary combustion is formed that can exceed 2,000+  
3 degrees Fahrenheit. At this temperature, contaminants and other material are burned  
4 completely thereby providing a clean and reduced pollution exhaust.

5  
6       In addition, silica in the form of liquid typically is formed on the inner walls of  
7 the secondary combustion chamber 40 that is collected within the silica collector 42 at  
8 the bottom of the secondary combustion chamber 40 as shown in Figures 1 and 4 of the  
9 drawings. The silica may be collected into various types of containers such as but not  
10 limited to carts.

11  
12       Alternatively, a liquid may be positioned within the silica container that  
13 pulverizes the silica chunks that fall into at an extreme temperature, where after the  
14 silica debris may be cleaned from the liquid. The silica collector 42 prevents the  
15 buildup of silica within the secondary combustion chamber 40 when straw and similar  
16 biomass are utilized with relatively high silica content.

#### 17 18 ***G. Heat Exchanger***

19       The heat exchanger 50 is fluidly connected to a lower portion of the secondary  
20 combustion chamber 40 as best shown in Figures 1 and 5 of the drawings. The heat  
21 exchanger 50 preferably includes a particle collector 52 for collecting particle waste  
22 remaining within the exhaust of the secondary combustion that falls downwardly from  
23 within the heat exchanger 50.

24  
25       It can be appreciated that a conventional heat exchanger 50 may be utilized that  
26 allows cool water to enter into pipes within the heat exchanger 50 that conduct the heat  
27 from the highly heated exhaust gas. The hot water then exits the heat exchanger 50 for  
28 use in producing electricity, heat for thermal applications and the like.

1       The preferred structure for a heat exchanger **50** is shown in Figure 5 wherein a  
2 fluid tank retaining a volume of water or other liquid has a plurality of exhaust pipes  
3 passing through thereof. The heated exhaust gas passes through the exhaust pipes  
4 within the fluid tank thereby heating the liquid within the fluid tank. An auger  
5 structure is utilized to remove collected particle waste from within the interior of the  
6 exhaust pipes.

#### 7 8 **H. Control Unit**

9       As shown in Figure 10 of the drawings, the control unit **12** is in communication  
10 with the oxygen mixer **30**, the disintegration unit **26**, the feeder unit **70**, the air  
11 distribution system **22**, the exhaust blower **62**, the drive motor **27** and the fuel  
12 conveyor **28**. The control unit **12** may be in communication with these devices via  
13 direct electrical connection, radio signal or other communication means.

14  
15       The control unit **12** also is in communication with various sensors **14** within the  
16 primary combustion chamber **20**, the secondary combustion chamber **40**, the heat  
17 exchanger **50** and the exhaust stack **60** to monitor the performance of the system and  
18 adjust the components accordingly. The control unit **12** may be comprised of a  
19 computer or other electronic device capable of storing various types of data including  
20 input data, program data and the like.

#### 21 22 **I. Operation**

23       In use, the biomass is loaded within the biomass storage bin **24**. The biomass is  
24 then automatically loaded into the biomass magazine **25** which then feeds the biomass  
25 into the disintegration unit **26**. The broken down biomass is then transferred along the  
26 conveyor **28** into the primary combustion chamber **20**. The biomass is fed into the  
27 input member **29** where after the plunger member **78** forces the biomass into the  
28 primary combustion chamber **20** onto the rotating grate **21** as shown in Figures 7a-7c  
29 of the drawings. The new biomass within the primary combustion chamber **20** is



1 thereafter broken down by the primary combustion within the primary combustion  
2 chamber 20 into producer gas. The producer gas rises to the upper portion of the  
3 interior of the primary combustion chamber 20 and then enters the transfer tube 32. As  
4 the producer gas passes through the transfer tube 32 a high velocity, the oxygen mixer  
5 30 inputs oxygen within the producer gas which is then dispersed into the upper  
6 portion of the secondary combustion chamber 40 where the secondary combustion  
7 occurs at a high temperature (exceeding 2,000 degree Fahrenheit). Silica and other  
8 debris is collected within the silica collector 42 at the bottom of the secondary  
9 combustion chamber 40. The super heated exhaust gas then enters the heat exchanger  
10 50 to heat a liquid or perform another function for transferring the heat energy. The  
11 cooled exhaust gas thereafter passes downwardly to a lower portion of an exhaust stack  
12 60 where an exhaust blower 62 assists in transferring the cooled exhaust gas outwardly  
13 through the exhaust stack 60.

14  
15 As to a further discussion of the manner of usage and operation of the present  
16 invention, the same should be apparent from the above description. Accordingly, no  
17 further discussion relating to the manner of usage and operation will be provided.

18  
19 With respect to the above description then, it is to be realized that the optimum  
20 dimensional relationships for the parts of the invention, to include variations in size,  
21 materials, shape, form, function and manner of operation, assembly and use, are  
22 deemed to be within the expertise of those skilled in the art, and all equivalent  
23 structural variations and relationships to those illustrated in the drawings and  
24 described in the specification are intended to be encompassed by the present invention.

25  
26 Therefore, the foregoing is considered as illustrative only of the principles of  
27 the invention. Further, since numerous modifications and changes will readily occur to  
28 those skilled in the art, it is not desired to limit the invention to the exact construction

1 and operation shown and described, and accordingly, all suitable modifications and  
2 equivalents may be resorted to, falling within the scope of the invention.  
3